Trend Analysis

Presented by

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Overview

- Purpose of a Trend Analysis
- Steps before plotting the data
- Basics and Fundamentals
- Trend Analysis Examples
- Conclusions

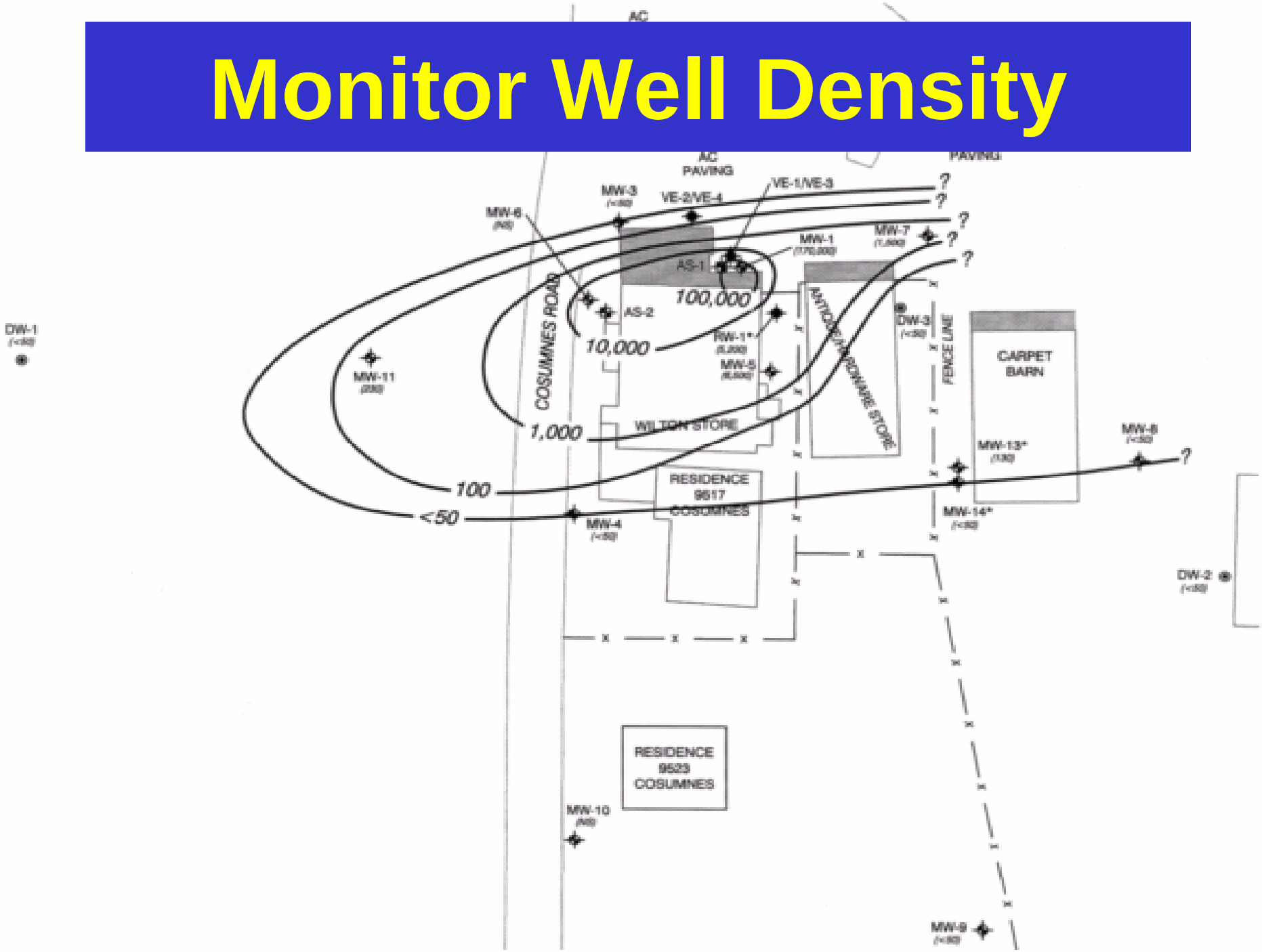
Purpose

- **Concentration vs. Time**
  - **The goal of a trend analysis is to determine if there is, in fact, a "trend" of increasing or decreasing concentrations in Site-Specific data**
- **Primary line of evidence to show concentrations are decreasing in groundwater with time**

Data Validation

- Highest degree of confidence in the data
- Field Procedures
  - –Monitor wells properly constructed and developed
  - –Well screens at the same depth interval
  - –Well screens across/below the water table
  - –How were wells sampled
    - •Bailers, Vac-truck, Down-hole pump
  - –Sampling techniques follow SAM Manual
- QA/QC the Lab data
  - –Did they use the appropriate analytical method
  - –COC procedures correct
  - –Holding times Met

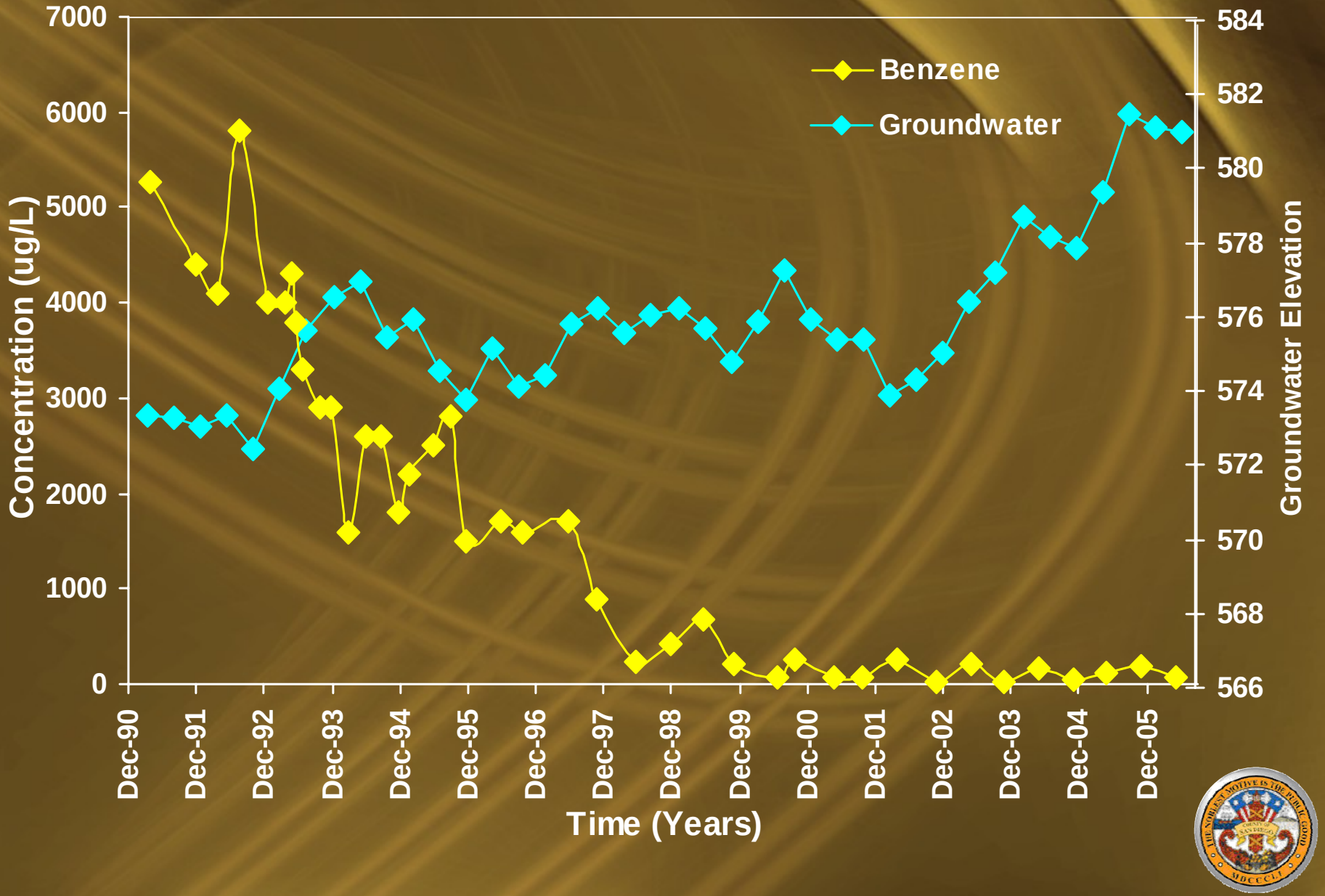
Monitor Well Density



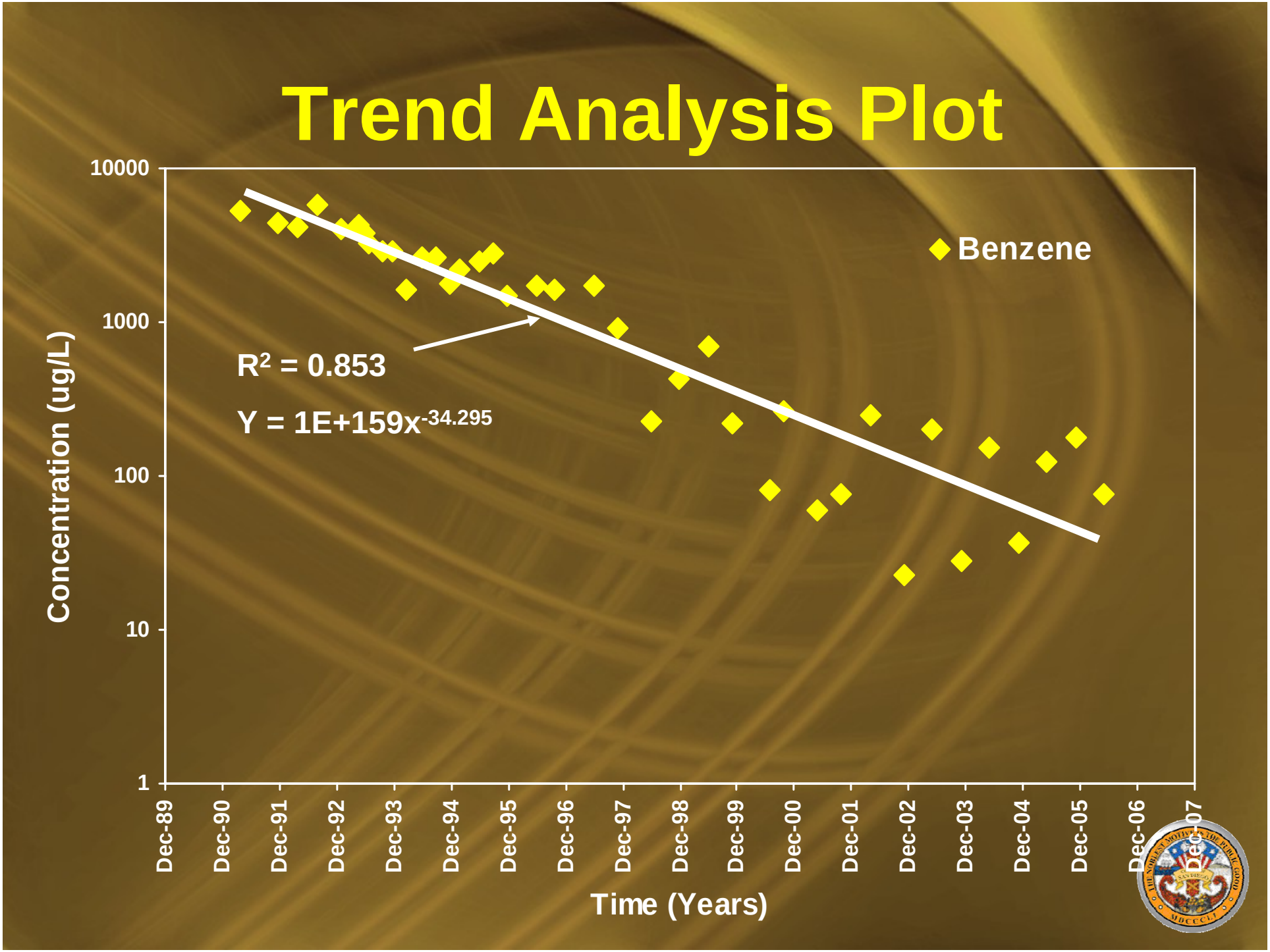
Basics & Fundamentals

- **Time Series Plot**
  - **Site specific data**
- **Trend Analysis Plot**
  - **Prepare a semi-logarithm plot of concentration vs *time***
- **All the analytical data for each well**
- **Remediation in a well**

Time Series Plot



Trend Analysis Plot



Decay Equation

- **First-order decay equation**

$$C = C_0 e^{-kt}$$

- **C = concentration at time t (ug/L)**
- **C_0 = peak concentration (ug/L)**
- **k = natural attenuation factor**
- **t = elapsed time after observation of peak concentration (years)**

R^2

- R^2 is restricted to linear relations
  - simply indicates how well the relation is described by a linear fit
- R^2 between 0.7 and 1
- A statistical test is the only way to assess the validity of such a trend
  - formally by conducting a hypothesis test of the hypothesis that the slope is less than zero (or greater than zero, or zero)
  - less formally by calculating the upper/lower confidence interval about the slope of the regression line

Trend Plot Examples

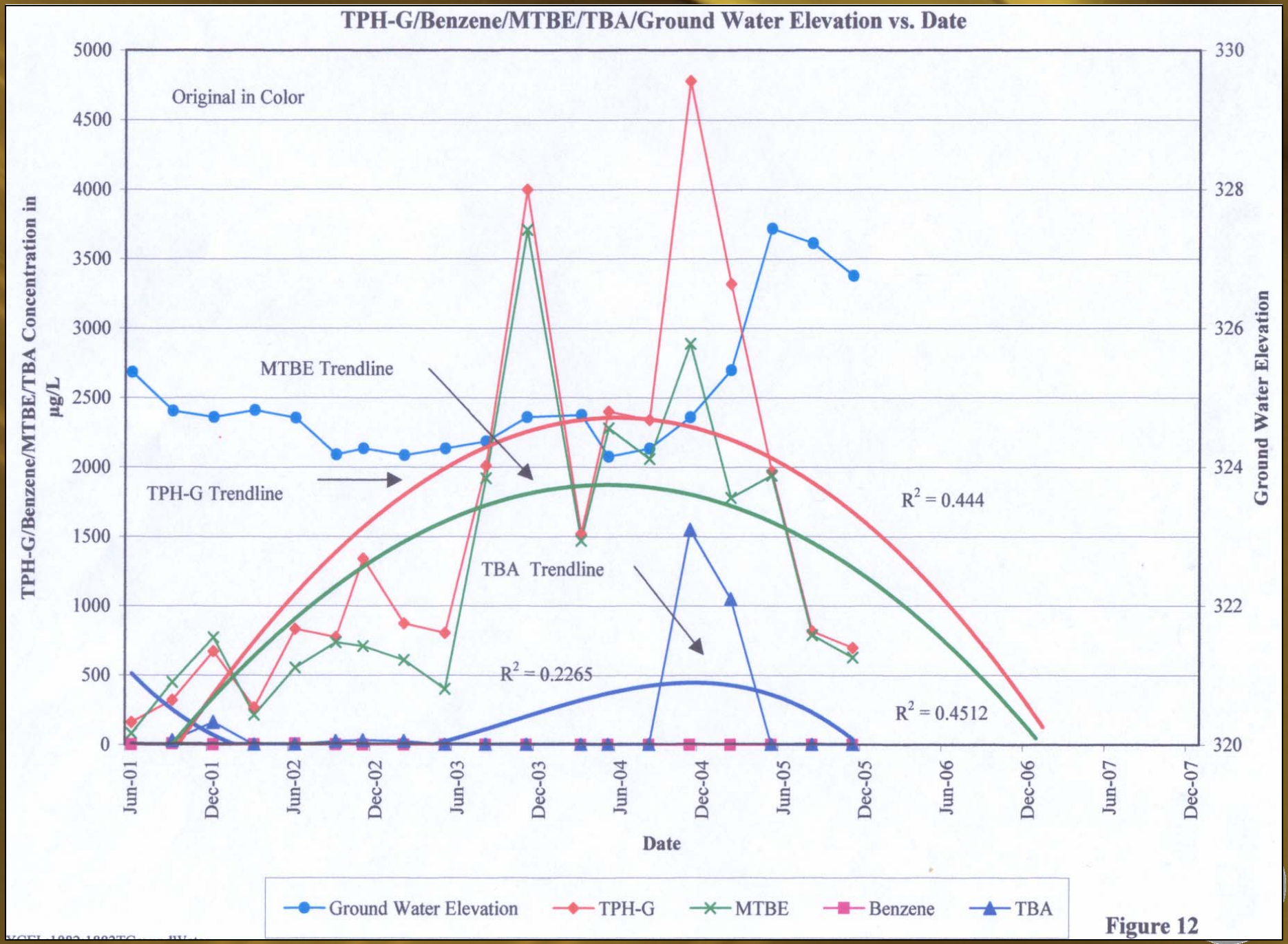

TPH-G/Benzene/MTBE/TBA/Ground Water Elevation vs. Date
Original in Color
MTBE Trendline
TPH-G Trendline
TBA Trendline
$R^2 = 0.444$
$R^2 = 0.2265$
$R^2 = 0.4512$
TPH-G/Benzene/MTBE/TBA Concentration in µg/L
Ground Water Elevation
Date
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
330
328
326
324
322
320
Jun-01
Dec-01
Jun-02
Dec-02
Jun-03
Dec-03
Jun-04
Dec-04
Jun-05
Dec-05
Jun-06
Dec-06
Jun-07
Dec-07
Ground Water Elevation
TPH-G
MTBE
Benzene
TBA

Figure 12

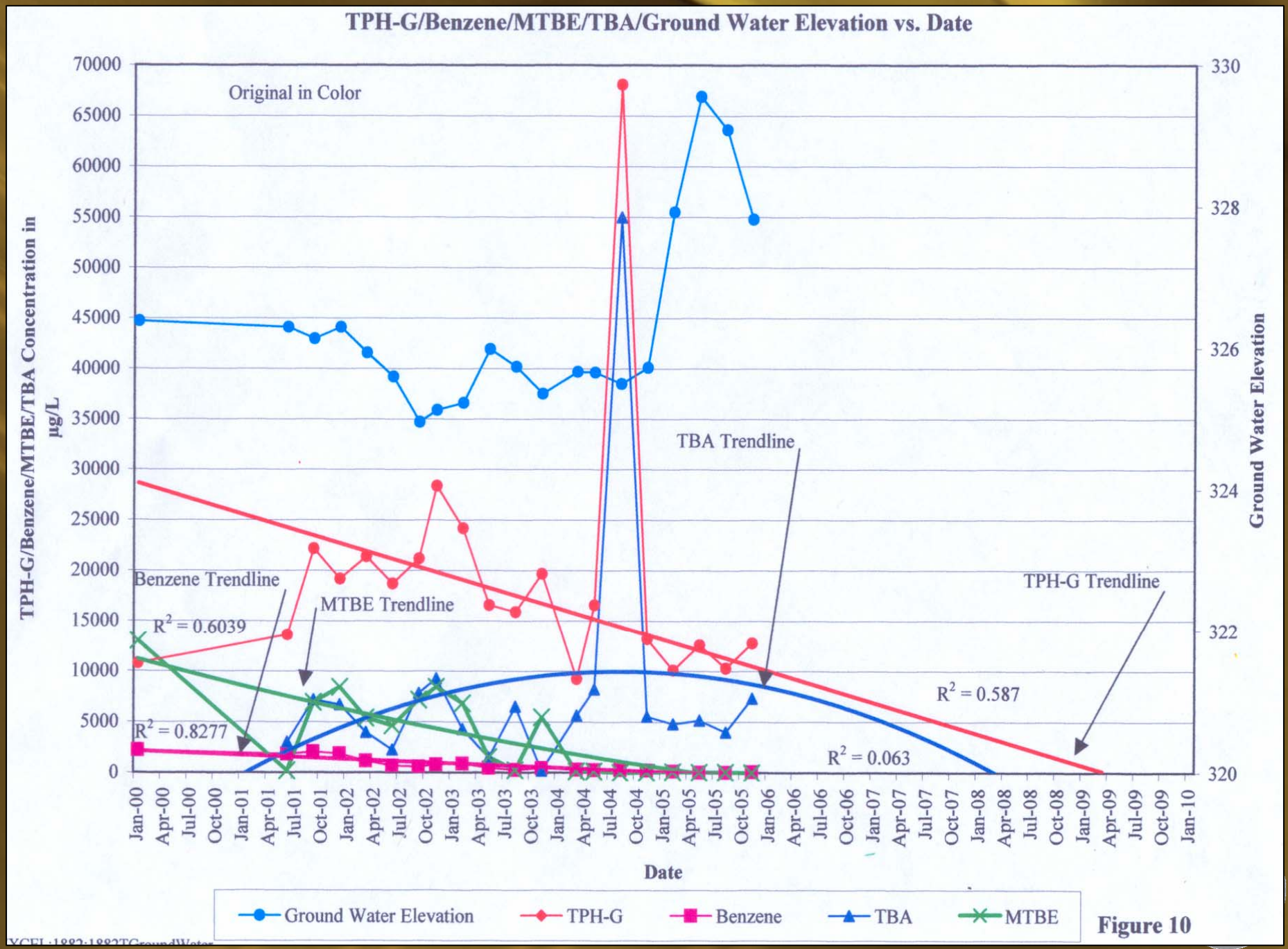
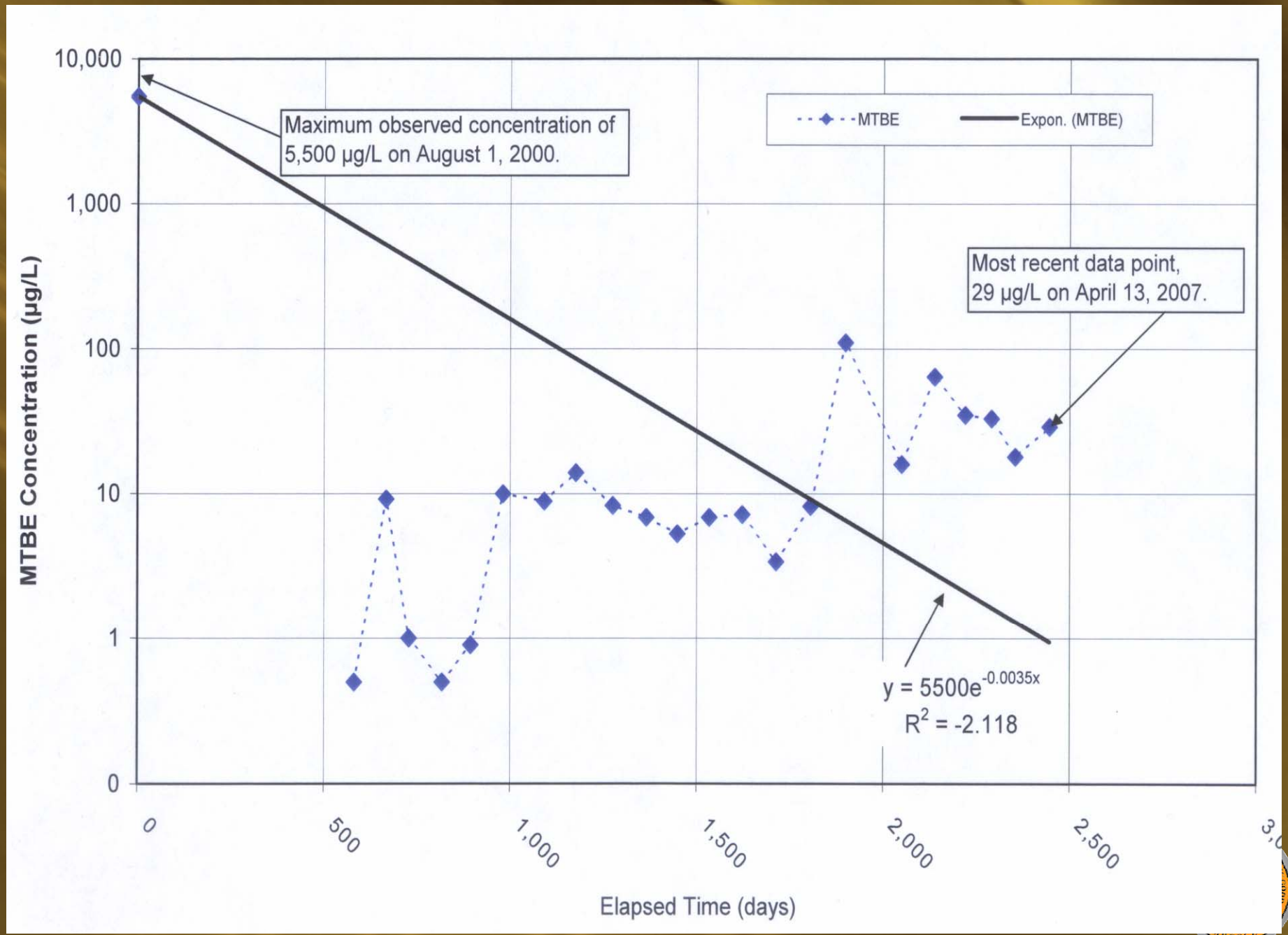
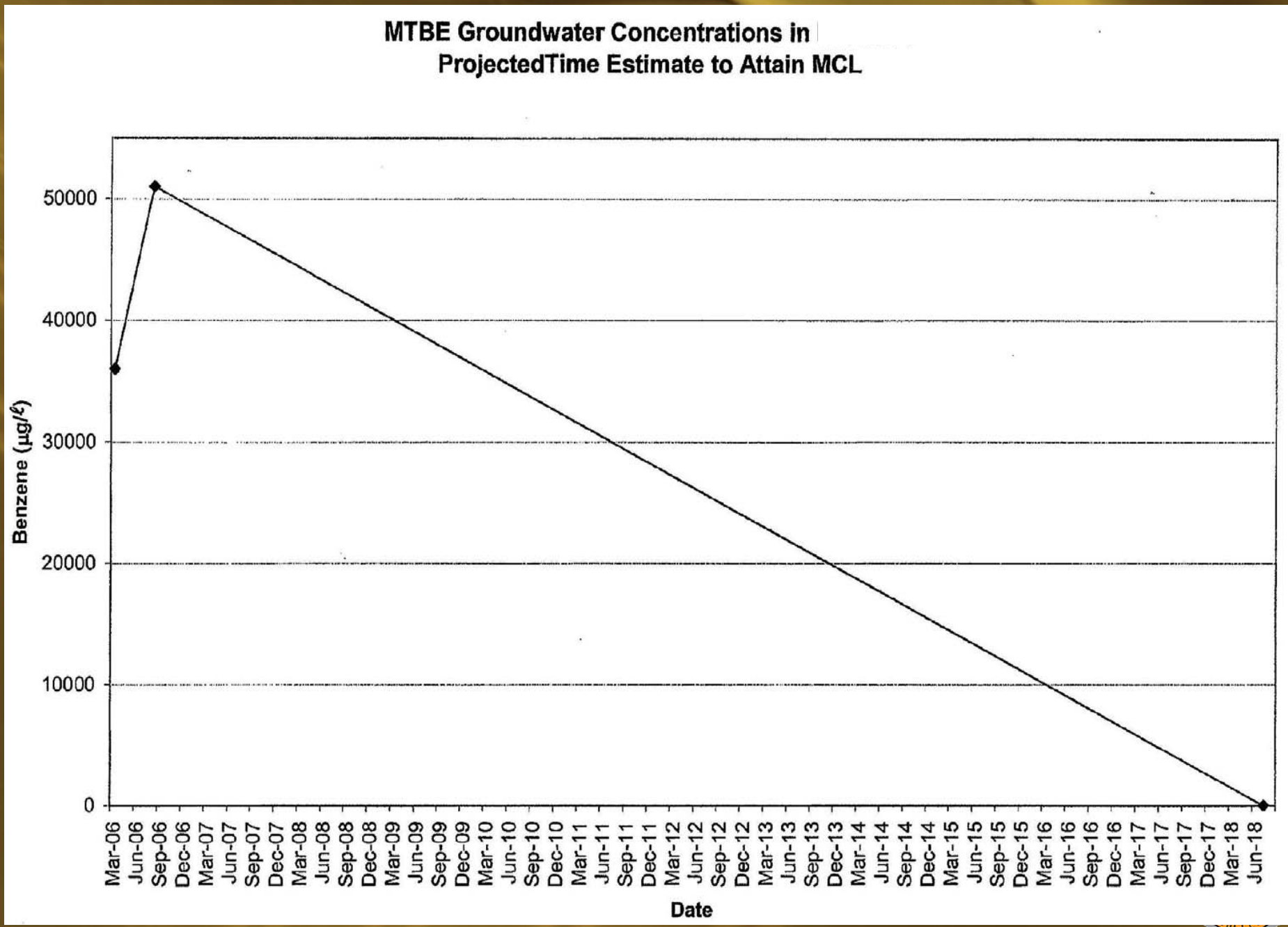
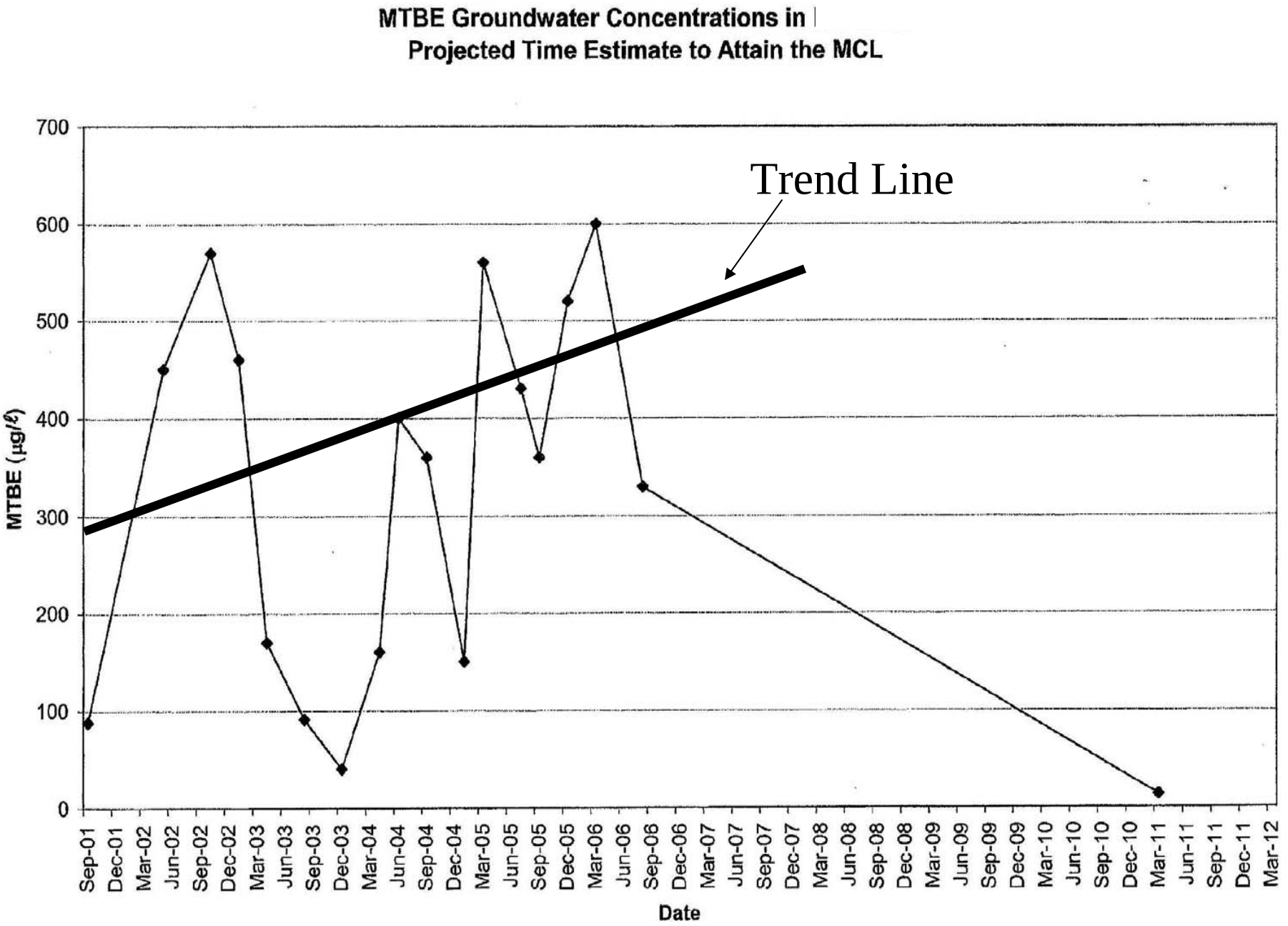
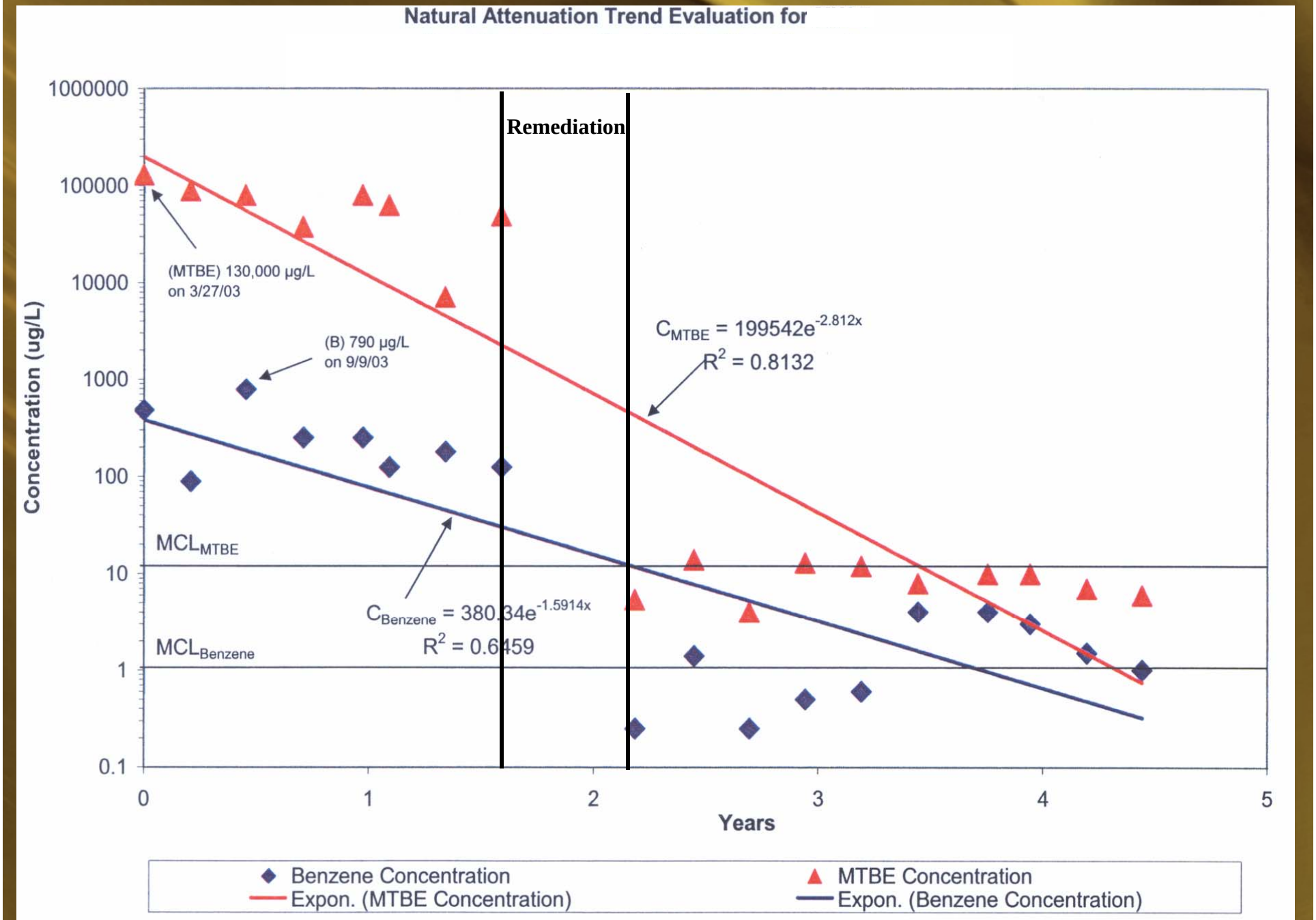

TPH-G/Benzene/MTBE/TBA/Ground Water Elevation vs. Date
Original in Color
TPH-G/Benzene/MTBE/TBA Concentration in µg/L
Ground Water Elevation
Date
TBA Trendline
Benzene Trendline
MTBE Trendline
TPH-G Trendline
R^2 = 0.6039
R^2 = 0.8277
R^2 = 0.587
R^2 = 0.063
Ground Water Elevation
TPH-G
Benzene
TBA
MTBE

Figure 10


10,000
1,000
100
10
1
0
MTBE Concentration (µg/L)
0
500
1,000
1,500
2,000
2,500
Elapsed Time (days)
MTBE
Expon. (MTBE)
Maximum observed concentration of 5,500 µg/L on August 1, 2000.
Most recent data point, 29 µg/L on April 13, 2007.
y = 5500e-0.0035x
R2 = -2.118


MTBE Groundwater Concentrations in
ProjectedTime Estimate to Attain MCL
Benzene (µg/ℓ)
50000
40000
30000
20000
10000
0
Mar-06
Jun-06
Sep-06
Dec-06
Mar-07
Jun-07
Sep-07
Dec-07
Mar-08
Jun-08
Sep-08
Dec-08
Mar-09
Jun-09
Sep-09
Dec-09
Mar-10
Jun-10
Sep-10
Dec-10
Mar-11
Jun-11
Sep-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
Dec-13
Mar-14
Jun-14
Sep-14
Dec-14
Mar-15
Jun-15
Sep-15
Dec-15
Mar-16
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Dec-17
Mar-18
Jun-18
Date


MTBE Groundwater Concentrations in
Projected Time Estimate to Attain the MCL
Trend Line
MTBE (µg/ℓ)
700
600
500
400
300
200
100
0
Sep-01
Dec-01
Mar-02
Jun-02
Sep-02
Dec-02
Mar-03
Jun-03
Sep-03
Dec-03
Mar-04
Jun-04
Sep-04
Dec-04
Mar-05
Jun-05
Sep-05
Dec-05
Mar-06
Jun-06
Sep-06
Dec-06
Mar-07
Jun-07
Sep-07
Dec-07
Mar-08
Jun-08
Sep-08
Dec-08
Mar-09
Jun-09
Sep-09
Dec-09
Mar-10
Jun-10
Sep-10
Dec-10
Mar-11
Jun-11
Sep-11
Dec-11
Mar-12
Date


Natural Attenuation Trend Evaluation for
Remediation
(MTBE) 130,000 µg/L
on 3/27/03
(B) 790 µg/L
on 9/9/03
$C_{MTBE} = 199542e^{-2.812x}$
$R^2 = 0.8132$
$C_{Benzene} = 380.34e^{-1.5914x}$
$R^2 = 0.6459$
MCL_{MTBE}
$MCL_{Benzene}$
Concentration (ug/L)
1000000
100000
10000
1000
100
10
1
0.1
0
1
2
3
4
5
Years
Benzene Concentration
MTBE Concentration
Expon. (MTBE Concentration)
Expon. (Benzene Concentration)

Conclusions

- Steps to consider before trend analysis
  - Validate the data
  - Well Density
- Time Series Plot
  - Discuss site specific data
- Trend Analysis Plot
  - Semi-Log Plot of concentrations vs. time
- Use multiple lines of evidence
- Call your Regulator if you have questions

QUESTIONS?